CHAPTER 18
Temperature

KEY TEACHING POINTS

- Both electronic thermometers (rectal, oral, axillary sites) and infrared thermometers (forehead and tympanic membrane) accurately measure body temperature, although variability is greatest with the tympanic thermometer. A temperature reading of 37.8°C or more using any of these instruments is abnormal and indicates fever.
- The patient's subjective report of fever is usually accurate.
- In patients with fever, the best predictors of bacteremia are the patient's underlying diseases (e.g., renal failure, hospitalization for trauma, and poor functional status all increase the probability of bacteremia). The presence of *shaking* chills also increases the probability of bacteremia. (A chill is shaking if the patient feels so cold that his or her body involuntarily shakes even under thick clothing or blanket.)
- Although classic fever patterns remain diagnostic in certain infections (e.g., typhoid fever and tertian malaria), the greatest value of fever patterns today rests with their response to antimicrobial agents. Persistence of fever despite an appropriate antibiotic suggests superinfection, drug fever, abscess, or a noninfectious mimic of an infectious disease (e.g., vasculitis, tumor).

I. INTRODUCTION

Fever is a fundamental sign of almost all infectious diseases and many noninfectious disorders. Clinicians began to monitor the temperature of febrile patients in the 1850s and 1860s, after Traube introduced the thermometer to hospital wards and Wunderlich published an analysis based on observation of an estimated 20,000 subjects that convinced clinicians of the value of graphing temperature over time.[1-3] These temperature charts, the first vital sign to be routinely recorded in hospitalized patients, were originally named **Wunderlich curves**.[4]

II. TECHNIQUE

A. SITE OF MEASUREMENT

Thermometers are used to measure the temperature of the patient's oral cavity, rectum, axilla, tympanic membrane, or forehead (i.e., temporal artery). Because of potential toxicity from mercury exposure, the time-honored mercury thermometer has been replaced by electronic thermometers with thermistors (oral, rectal, and axillary measurements) and infrared thermometers (tympanic or forehead measurements). These instruments provide more rapid results than the traditional mercury thermometer.

Normal body temperature varies widely, depending in part on the site measured. Rectal readings are on average 0.4 to 0.6°C higher than oral ones, which are 0.1 to 0.2°C higher than axillary readings.[5-8] Temporal (forehead) measurements typically fall between rectal and oral readings.[7,9] Tympanic readings are the most variable, with some studies showing them to be systematically higher than rectal readings[10] and others showing them to be systematically lower than oral readings.[11]

Even so, these studies, which are designed to detect *systematic differences* between instruments, do not reflect the variability observed in individual patients. For example, comparisons of sequential rectal and oral readings measured in large numbers of patients reveal the *rectal-minus-oral difference* to be 0.6 ± 0.5°C.[10] This indicates that *on average* rectal readings are 0.6°C greater than oral readings (i.e., the *systematic difference*), but it also indicates that the rectal reading of a particular patient may vary from as much as 0.4°C *lower* than the oral reading to 1.6°C *higher* than the oral reading.* Similar variability is observed when any of the five sites are compared in the same patient (e.g., oral vs. temporal, axillary vs. rectal, etc.).

A better question is how well different instruments detect infection. In one study of elderly patients presenting to an emergency department, three different techniques—rectal, temporal, and tympanic measurements—had similar diagnostic accuracy for infection (likelihood ratios [LRs] 4.2 to 8.5; EBM Box 18.1), although each instrument had a different definition of fever (rectal *T* >37.8°C; forehead *T* >37.9°C; tympanic *T* >37.5°C).[9]

EBM BOX 18.1

Temperature Measurement at Different Sites, Detecting Infection[*9]

Finding (Reference)	*Sensitivity (%)*	*Specificity (%)*	**Likelihood Ratio if Finding Is**	
			Present	*Absent*
Rectal temperature >37.8°C	44	93	**6.1**	0.6
Forehead temperature >37.9°C	38	91	**4.2**	0.7
Tympanic temperature >37.5°C	34	96	**8.5**	0.7

*Diagnostic standard: for *infection,* consensus diagnosis from chart review.
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*This is calculated as follows: The 95% confidence interval (CI) equals 2 × standard deviation (i.e., 2 × 0.5°C = 1°C). A rectal-minus-oral difference of 0.6 ± 0.5°C, therefore, indicates the variation ranges from −0.4 (i.e., 0.6 − 1.0; rectal is 0.4°C lower than oral) to +1.6 (i.e., 0.6 + 1.0; rectal is 1.6°C higher than oral).

B. VARIABLES AFFECTING THE TEMPERATURE MEASUREMENT

1. EATING AND SMOKING[5,12-14]

The *oral* temperature measurement increases about 0.3°C after sustained chewing and stays elevated for up to 20 minutes, probably because of increased blood flow to the muscles of mastication. Drinking hot liquids also increases oral readings about 0.6 to 0.9°C, for up to 15 to 25 minutes, and smoking a cigarette increases oral readings about 0.2°C for 30 minutes. Drinking ice water causes the oral reading to fall 0.2 to 1.2°C, a reduction lasting about 10 to 15 minutes.

2. TACHYPNEA

Tachypnea reduces the *oral* temperature reading about 0.5° C for every 10 breaths/minute increase in the respiratory rate.[15,16] This phenomenon probably explains why marathon runners, at the end of their race, often have a large discrepancy between normal oral temperatures and high rectal temperatures.[17]

In contrast, the administration of oxygen by nasal cannula does not affect oral temperature.[18]

3. CERUMEN

Cerumen lowers *tympanic* temperature readings by obstructing the radiation of heat from the tympanic membrane.[5]

4. HEMIPARESIS

In patients with hemiparesis, *axillary* temperature readings are about 0.5°C lower on the weak side compared with the healthy side. The discrepancy between the two sides correlates poorly with the severity of the patient's weakness, suggesting that it is not due to difficulty holding the thermometer under the arm, but instead to other factors, such as differences in cutaneous blood flow between the two sides.[19]

5. MUCOSITIS

Oral mucositis, a complication of chemotherapy, increases oral readings on average by 0.7°C,[20] even without fever. This increase in temperature likely reflects inflammatory vasodilation of the oral membranes.

III. THE FINDING

A. NORMAL TEMPERATURE AND FEVER

In healthy persons, the mean oral temperature is 36.5°C (97.7°F), a value slightly lower than Wunderlich's original estimate of 37°C (98.6°F), which in turn had been established using foot-long axillary thermometers that may have been calibrated higher than the thermometers used today.[1] The temperature is usually lowest at 6 am and highest at 4 to 6 pm (a variation called *diurnal variation*).[21] One investigator has defined fever as the 99th percentile of maximum temperatures in healthy persons, or an *oral* temperature greater than 37.7°C (99.9°F).[21] Most studies show that a temperature greater than 37.8°C with any instrument is abnormal (and therefore indicative of fever).[6]

B. FEVER PATTERNS

In the early days of clinical thermometry, clinicians observed that prolonged fevers could be categorized into one of four fever patterns—sustained, intermittent, remittent, and relapsing (Fig. 18.1).[3,22-24] **(1) Sustained fever.** In this pattern the fever varies

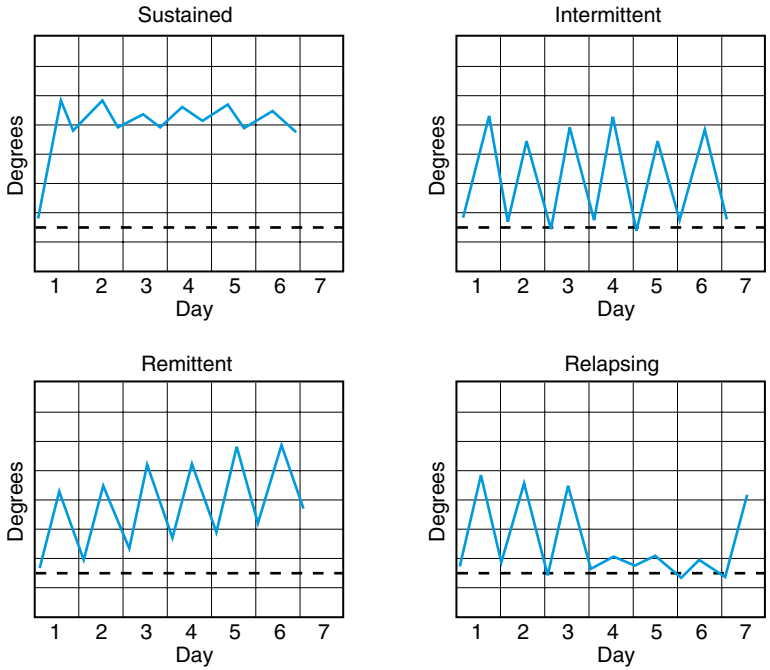

FIG. 18.1 FEVER PATTERNS. The four basic fever patterns are sustained, intermittent, remittent, and relapsing fever. The *dashed line* in each chart depicts normal temperature. See text for definitions and clinical significance.

little from day to day (the modern definition is variation ≤0.3°C [≤0.5°F] each day); (2) **Intermittent fever.** In this pattern the temperature returns to normal between exacerbations. If the exacerbations occur daily, the fever is *quotidian*; if they occur every 48 hours, it is *tertian* (i.e., they appear again on the third day); and if they occur every 72 hours, it is *quartan* (i.e., they appear again on the fourth day). (3) **Remittent.** Remittent fevers vary at least 0.3°C (0.5°F) each day but do not return to normal. **Hectic fevers** are intermittent or remittent fevers with wide swings in temperature, usually greater than 1.4°C (2.5°F) each day. (4) **Relapsing fevers.** These fevers are characterized by periods of fever lasting days interspersed by equally long afebrile periods.

Each of these patterns was associated with prototypic diseases: sustained fever was associated with lobar pneumonia (lasting 7 days until it disappeared abruptly by *crisis* or gradually by *lysis*); intermittent fever with malarial infection; remittent fever with typhoid fever (causing several days of ascending remittent fever, whose curve resembles climbing steps before becoming sustained); hectic fever with chronic tuberculosis or pyogenic abscesses; and relapsing fever with relapse of a previous infection (e.g., typhoid fever). Other causes of relapsing fever are the Pel-Ebstein fever of Hodgkin disease,[25] rat-bite fever (*Spirillum minus* or *Streptobacillus moniliformis*),[26] and *Borrelia* infections.[27]

Despite these etiologic associations, early clinicians recognized that the diagnostic significance of fever patterns was limited.[28] Instead, they used these labels more often to communicate a specific observation at the bedside rather than imply a specific diagnosis, much like we use the words "systolic murmur" or "lung crackle" today.

C. ASSOCIATED FINDINGS

1. FOCAL FINDINGS

Over 80% of patients with bacterial infections have specific focal signs or symptoms that point the clinician to the correct diagnosis.[29] There are countless focal signs associated with febrile illness (e.g., the tender swelling of an abscess or the diastolic murmur of endocarditis), which are reviewed in detail in infectious diseases textbooks. One potentially misleading focal sign, however, is jaundice. Although fever and jaundice are often due to hepatitis or cholangitis, jaundice is also a nonspecific complication of bacterial infection distant to the liver, occurring in 1% of all bacteremias.[30,31] This *reactive hepatopathy of bacteremia* was recognized over a century ago by Osler, who wrote that jaundice appeared in pneumococcal pneumonia with curious irregularity in different outbreaks.[28]

2. RELATIVE BRADYCARDIA

Relative bradycardia, a traditional sign of intracellular bacterial infections (e.g., typhoid fever), refers to a pulse rate that is inappropriately slow for the patient's temperature. One definition is a pulse rate that is lower than the 95% confidence limit for the patient's temperature, which can be estimated by multiplying the patient temperature in degrees Celsius times 10 and then subtracting 323.[32] For example, if the patient's temperature is 39°C, relative bradycardia would refer to pulse rates below 67/minute (i.e., 390 – 323).[†]

3. ANHIDROSIS

Classically, patients with heat stroke have "bone-dry skin," but most modern studies show that anhidrosis appears very late in the course and has a sensitivity of only 3% to 60%.[33-35] In contrast, 91% of patients with heat stroke have significant pyrexia (exceeding 40°C), and 100% have abnormal mental status.

4. MUSCLE RIGIDITY

Muscle rigidity suggests the diagnosis of neuroleptic malignant syndrome (a febrile complication from dopamine antagonists) or serotonin syndrome (from proserotonergic drugs).[36,37]

IV. CLINICAL SIGNIFICANCE

A. DETECTION OF FEVER

Two findings increase the probability of fever: the patient's subjective report of fever (LR = 5.3) and the clinician's perception that the patient's skin is abnormally warm (LR = 2.8; EBM Box 18.2). When either of these findings is absent, the probability of fever decreases (LR = 0.2 to 0.3).

B. PREDICTORS OF BACTEREMIA IN FEBRILE PATIENTS

In patients hospitalized with fever, 8% to 37% will have documented bacteremia,[43,44,46,47,49,50,54,57,58] a finding associated with an increased hospital mortality.[59] Of all the bedside findings that help diagnose bacteremia, the most important are the patient's underlying disorders, in particular the presence of renal failure (LR = 4.6; EBM Box 18.3), hospitalization for trauma (LR = 3), and poor functional status (i.e., bedridden or requiring

[†]This formula combines separate formulas for women (<11 × T°C – 359) and men (<10.2 × T°C – 333) provided in reference 32, which in turn were based on observations of 700 febrile patients.

EBM BOX 18.2
*Detection of Fever**

Finding (Reference)	*Sensitivity (%)*	*Specificity (%)*	*Likelihood Ratio† if Finding Is*	
			Present	*Absent*
Patient's report of fever[38-40]	80-90	55-95	**5.3**	**0.2**
Patient's forehead abnormally warm[39,41,42]	67-85	72-74	2.8	**0.3**

*Diagnostic standard: for *fever,* measured axillary temperature >37.5°C,[39,42] oral temperature >38°C,[38,40] or rectal temperature >38.1°C.[41]
†Likelihood ratio (LR) if finding present = positive LR; LR if finding absent = negative LR.
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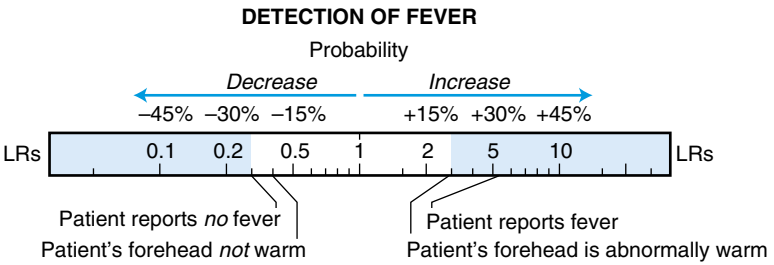

EBM BOX 18.3
*Detection of Bacteremia in Febrile Patients**

Finding (Reference)†	*Sensitivity (%)*	*Specificity (%)*	*Likelihood Ratio‡ if Finding Is*	
			Present	*Absent*
Risk Factors				
Age 50 years or more[29,43]	89-95	32-33	1.4	**0.3**
Renal failure[44]	19-28	95	**4.6**	0.8
Hospitalization for trauma[45,46]	12-63	79-98	**3.0**	NS
Intravenous drug use[47,48]	2-7	98-99	NS	NS
Previous stroke[44]	17	94	2.8	NS
Diabetes mellitus[29,43,44,48-53]	17-38	77-90	1.6	0.9
Poor functional performance[44]	48-61	83-87	**3.6**	0.6
Rapidly fatal disease (<1 month)[47,54]	2-30	88-99	2.7	NS

EBM BOX 18.3—cont'd
*Detection of Bacteremia in Febrile Patients**

Finding (Reference)†	Sensitivity (%)	Specificity (%)	Likelihood Ratio‡ if Finding Is Present	Likelihood Ratio‡ if Finding Is Absent
Physical Examination				
Indwelling Lines and Catheters				
Indwelling urinary catheter present[43,44,48-50]	3-38	83-99	2.7	NS
Central intravenous line present[46,48,55,56]	8-24	90-97	2.4	NS
Vital Signs				
Temperature ≥38.5°C[50,56]	62-87	27-53	1.2	0.7
Tachycardia[46,49,52,56]	57-73	40-56	1.2	0.7
Respiratory rate >20/minute[49,52]	37-65	30-74	NS	NS
Hypotension[47,49,50,52,53,56]	7-38	82-99	2.3	0.9
Other Findings				
Acute abdomen[47,54,55]	2-20	90-100	1.7	NS
Confusion or depressed sensorium[46,49-51,53,55]	5-52	68-96	1.6	NS

*Diagnostic standard: for *bacteremia*, true bacteremia (not contamination), as determined by number of positive cultures, organism type, and results of other cultures.
†Definition of findings: for *renal failure,* serum creatinine >2 mg/dL for *rapidly fatal disease,* >50% probability of fatality within 1 month (e.g., relapsed leukemia without treatment, hepatorenal syndrome); for *poor functional status*, see text; for *tachycardia*, pulse rate >90 beats/minute[46] or >100 beats/min[49,52]; for *hypotension*, systolic blood pressure <100 mm Hg,[49] <90 mm Hg,[47,52,53,56] or "shock."[50]
‡Likelihood ratio (LR) if finding present = positive LR; LR if finding absent = negative LR.
NS, Not significant.
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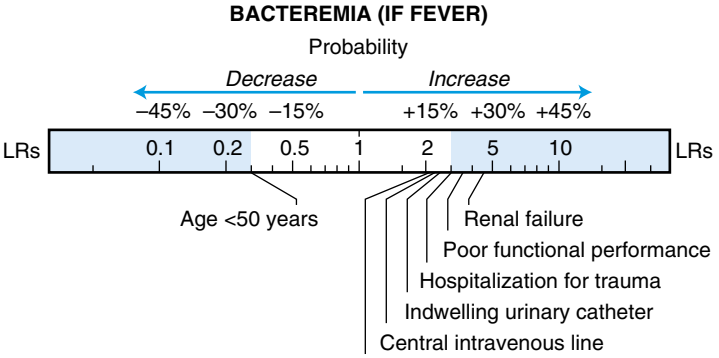

attendance; LR = 3.6).‡ One study even showed that the amount of food consumed by a febrile hospitalized patient was predictive of bacteremia: low food consumption (i.e., less than half of the meal served just before the blood culture) increased the probability of bacteremia (LR = 2.3), whereas high food consumption (more than 80% consumed) decreased it (LR = 0.2).[66] A few physical findings also modestly increase the probability of bacteremia: presence of an indwelling urinary catheter (LR = 2.7), presence of a central venous catheter (LR = 2.4), and hypotension (LR = 2.3). The only finding significantly decreasing the probability of bacteremia is age under 50 years (LR = 0.3).

In 11 studies of over 6000 patients with fever, the presence of **chills** modestly increased the probability of bacteremia (sensitivity 24% to 95%; specificity 45% to 88%; positive LR = 1.9; negative LR = 0.7).[44,47,49-55,67,68] If chills are instead prospectively defined as **shaking chills** (i.e., the patient feels so cold that his or her body involuntarily shakes even under thick clothing or blanket), the finding of shaking chills accurately detects bacteremia (sensitivity 45% to 90%, specificity 74% to 90%, positive LR = 3.7).[52,69] The presence of **toxic appearance** fails to discriminate serious infection from trivial illness.[29,70]

C. EXTREME PYREXIA AND HYPOTHERMIA

Extreme pyrexia (i.e., temperature exceeding 41.1°C [106°F]) has diagnostic significance because the cause is usually gram-negative bacteremia or problems with temperature regulation (heat stroke, intracranial hemorrhage, severe burns).[35]

In a wide variety of disorders, the finding of a very high or low temperature indicates a worse prognosis.[71,72] For example, temperatures greater than 39°C are associated with an increased risk of death in patients with pontine hemorrhage (LR = 23.7; EBM Box 18.4). Very low temperatures are associated with an increased risk of death in patients hospitalized with congestive heart failure (LR = 6.7), pneumonia (LR = 3.5), and bacteremia (LR = 3.3).

D. FEVER PATTERNS

Most fevers today, whether infectious or noninfectious in origin, are intermittent or remittent and lack any other characteristic feature.[73,74] Antibiotic medications have changed many traditional fever patterns. For example, the fever of lobar pneumonia, which in the preantibiotic era was sustained and lasted 7 days, now lasts only 2 to 3 days.[75,76] The double quotidian fever pattern (i.e., 2 daily fever spikes), a feature of gonococcal endocarditis present in 50% of cases during the preantibiotic era, is consistently absent in reported cases from the modern era.[77] The characteristic tertian or quartan intermittent fever of malaria infection also is uncommon today, because most patients are treated before the characteristic synchronization of the malaria cycle.[78]

Nonetheless, although traditional fever patterns may be less common, they still have significance. In tropical countries, the presence of the stepladder remittent pattern of fever is highly specific for the diagnosis of typhoid fever (LR = 177.4).[79] Also, among travelers with malarial infection who reported a tertian pattern, most are infected with *Plasmodium vivax* (traditionally the most common cause of this pattern).[80]

Moreover, the antibiotic era has given fever patterns a new significance, because once antibiotics have been started, the finding of an unusually prolonged fever is an important sign indicating either that the diagnosis of infection was incorrect (e.g.,

‡For comparison, the LRs of these findings are superior to those for traditional laboratory signs of bacteremia, such as leukocytosis and bandemia. In detecting bacteremia, a WBC greater than 15,000 has an LR of only 1.6,[29,43,49,60] whereas a band count greater than 1500 has an LR of 2.6.[29,43,50]

EBM BOX 18.4
Extremes of Temperature and Prognosis

*Finding (Reference)**	*Sensitivity (%)*	*Specificity (%)*	*Likelihood Ratio† if Finding Is*	
			Present	*Absent*
Temperature >39°C				
Predicting hospital mortality in patients with pontine hemorrhage[61]	66	97	**23.7**	0.4
Hypothermia*				
Predicting hospital mortality from pump failure in patients with congestive heart failure[62]	29	96	**6.7**	NS
Predicting hospital mortality in patients with pneumonia[63,64]	14-43	93	**3.5**	NS
Predicting hospital mortality in patients with bacteremia[65]	13	96	**3.3**	NS

*Definition of findings: for *hypothermia,* temperature <35.2°C,[62] <36.1°C,[64] <36.5°C,[65] or <37.0°C.[63]

†Likelihood ratio (LR) if finding present = positive LR; LR if finding absent = negative LR.

NS, Not significant.

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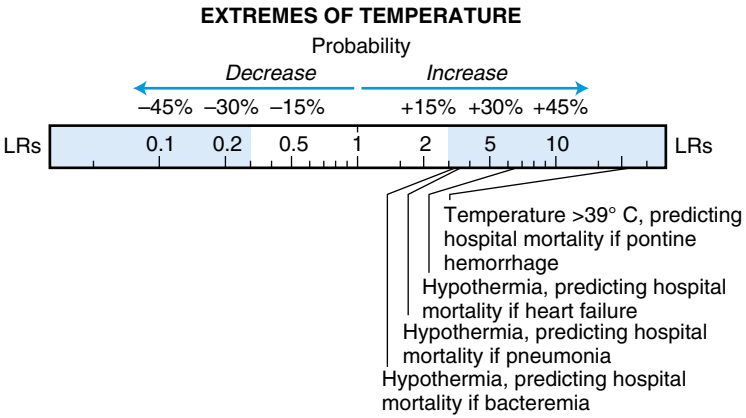

the patient instead has a connective tissue disorder or neoplasm) or that the patient has one of several complications, such as resistant organisms, superinfection, drug fever, or an abscess requiring surgical drainage.

E. RELATIVE BRADYCARDIA

Clinical studies demonstrate that some infections, such as intracellular bacterial infections (e.g., typhoid fever and Legionnaire disease) and arboviral infections (e.g., sandfly fever and dengue fever) do produce less tachycardia than other infections, but few patients with these infections actually have a relative bradycardia as defined earlier in the Findings section. Nonetheless, in one study of 100 febrile patients admitted to a Singapore hospital, a pulse rate of 90/minute or less increased the probability of dengue infection (LR = 3.3) and a pulse rate of 80/minute or less increased the probability even more (LR = 5.3).[81]

F. FEVER OF UNKNOWN ORIGIN

Fever of unknown origin (FUO) is defined as a febrile illness lasting at least 3 weeks without an explanation after at least 1 week of investigation. Most etiologies of FUO are noninfectious, particularly malignancies and noninfectious inflammatory disorders. In three studies of almost 300 patients with FUO, two physical findings modestly increased the probability that a bone marrow examination would be diagnostic (usually of a hematologic malignancy): splenomegaly (sensitivity 35% to 53%; specificity 82% to 89%; LR = 2.9) and peripheral lymphadenopathy (sensitivity 21% to 30%; specificity 83% to 90%; LR 1.9).[82-84]

The references for this chapter can be found on www.expertconsult.com.

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